Bite Force and Masticatory Efficiency in Implant-Retained Dentures

Literature Review

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INTRODUCTION

Patients who wear conventional dentures often complain about the instability of the prostheses, particularly the mandibular denture. Denture instability leads to a feeling of insecurity, inefficient mastication, and overall dissatisfaction with the prosthesis.1-3 Implant-retained dentures have been developed and studied as a method for solving the problem of instability associated with conventional dentures.4,5 Both fixed and removable implant-retained full dentures have evolved over the past 15 years.

Implant-retained dentures have many advantages compared to conventional dentures. The instability of mandibular dentures increases with the severity of mandibular atrophy.6 Physical retention is limited in patients with significant bone resorption, since the supporting surface is greatly reduced and stability of the lower denture is provided mainly by the action of the musculature.7 Anatomical or financial limitations may preclude the use of a fixed implant-retained prosthesis. In these cases a removable implant-retained denture with a limited number of implants may be possible.

This article reviews the literature to assess treatment outcomes of implant-retained dentures versus conventional dentures in terms of masticatory efficiency, stability, and patient satisfaction.

LITERATURE REVIEW

Different Designs of Posterior Teeth

The occlusal design of artificial teeth used in dentures has generated controversy. It has long been recognized that the occlusal design of posterior teeth does affect the masticatory efficiency of complete dentures.8-12 This is confirmed in natural teeth; Sauser and Yurkstas13 demonstrated that the occlusal anatomy of teeth was found to be directly related to chewing efficiency. However, there is some disagreement regarding the importance of occlusal design, with some clinicians believing that different occlusal designs do not significantly affect masticatory efficiency of complete dentures.14-18 They base this belief on the movement of conventional mandibular denture bases that are supported by compressed soft tissue. Specifically,
some believe that resilient tissue support causes movement of the complete denture base, thus minimizing the effect of occlusal design. However, with the introduction of implant-retained dentures, stability, bite force, and masticatory efficiency improved as compared to conventional dentures. In terms of the occlusal design of posterior teeth, it has been suggested that the reduction of cusp inclination limits lateral forces, and is therefore beneficial for preservation of implant osseointegration.

Kaukinen, et al determined that with an implant-retained prosthesis the initial force required to break up a bolus of food was 50% less when the cusps had a zero-degree incline compared to cusps with an incline of 33º (Figure 1). They explained that as the complexity of an occlusal design increases, the potential is greater for wedging of food and increased force transmission to implant-retained prostheses. However, there were no significant differences in maximum force or maximum pressure applied during mastication for the 2 types of denture teeth.

For implant-retained dentures, Lang and Razzoog recommended lingualized posterior occlusion based on the advantages of this design found in conventional dentures. Khamis, et al compared 3 occlusal forms—zero-degree cusp incline, cusp incline of 30º, and lingualized occlusion—in subjects with mandibular implant overdentures. One maxillary and 3 mandibular dentures with different occlusal forms were constructed for each patient. Masticatory efficiency, effect on implant-supporting tissues, and patient satisfaction were evaluated. The authors determined that the occlusal form and the position of the posterior teeth do not have to be chosen based on criteria used for conventional denture bases. The chewing efficiency tests and patient preference ratings showed that 30º teeth and lingual contact were better than zero-degree teeth. None of the tested occlusal forms were associated with adverse clinical or radiographic effects on the implant-supporting tissues.

Masticatory Efficiency

Patients often complain about the stability and retention of their conventional mandibular dentures. Masticatory function is often poor; in fact, the masticatory force is 20% to 40% of that of healthy dentate subjects. Consequently, patients with dentures may have a diet deficient in fiber and vitamins. Complete denture wearers need up to 7 times more chewing strokes to reduce food to half of its original particle size than do subjects with a complete, natural dentition. Oral function improves significantly after fabrication of a mandibular implant overdenture. Subjects with mandibular implant-supported overdentures need 1.5 to 3.6 times fewer chewing strokes than conventional complete denture wearers to obtain an equivalent reduction in food particle size. This is because the maximum masticatory force of an implant-retained denture is 60% to 200% greater than that of a conventional denture.

Chewing cycles in the traditionally rehabilitated edentulous patient are irregular in shape and smaller in size than those of subjects with a healthy dentition. Stabilizing the denture with implants has been found to produce chewing cycles that are more regularly shaped, more uniform, and larger.

To test the hypothesis that a fixed implant-retained prosthesis is more efficient than a removable prosthesis, Feine, et al studied patient perceptions, mandibular movements, electromyography, and masticatory efficiency of patients rehabilitated with a mandibular fixed implant-retained prosthesis and an overdenture (over-bar). Interestingly, the overdentures were not less efficient than the fixed implant-retained prostheses. This suggests that patients are capable of adapting to different prostheses.

Bakke, et al in a 5-year study evaluated the masticatory function and patient satisfaction with implant-supported mandibular overdentures. Based on functional recordings with the new dentures at 3 months, 1 year, and 5 years, the study verified that after 5 years all patients were capable of grinding hard food, that the maximum bite force...
force and masticatory function increased over time with the use of the overdentures, and that the duration of the chewing cycle decreased. All patients felt better about masticatory function and experienced less pain during mastication with the use of overdentures.

Fontijn-Tekamp, et al\(^2^6\) evaluated the bite force and masticatory efficiency of overdentures, conventional complete dentures, and natural teeth. The results indicated that the masticatory force acquired with overdentures is more than conventional dentures and less than natural teeth.

To test the hypothesis that better retention and stability of the denture improve masticatory function, van Kampen, et al\(^3^1\) designed a within-subject cross-over clinical trial to study the effects of 3 mandibular implant overdenture suprastructure designs using 3 types of attachments: magnet, bar-clip, and ball attachments. They demonstrated that maximum bite force nearly doubles after implant treatment with the 3 designs, while no significant differences in maximum bite force occurred among the 3 attachment types. Subsequently, the same authors\(^3\) observed small differences in masticatory function when comparing the 3 attachments. There was slightly better masticatory performance with the ball and the bar-clip than with magnet attachments. The number of chewing cycles required before swallowing decreased slightly after implant treatment.

Van der Bilt, et al\(^3^2\) affirmed that good oral function depends on the retention, stability, and the attachment of the denture. However, studying the 3 types of attachments (magnet, ball, and bar-clip), they did not observe differences in function.\(^3^2\)

Stellingsma, et al\(^3^3\) analyzed the effects of implant-supported overdentures on masticatory function in patients with extremely resorbed mandibles, and compared masticatory function using 3 differing types of implant treatment protocols (Figures 2 and 3). Masticatory function was assessed before and after treatment using a questionnaire, a masticatory performance test, and a structured interview. It was concluded that there was a significant improvement in masticatory function after implant-overdenture treatment. However, the differences in masticatory function between the 3 modalities were not significant after treatment, regardless of the number of implants.

Patient Satisfaction

Evaluation of patient satisfaction is controversial because of the subjective nature of the analysis. However, there is a trend in the literature that overdentures have greater stability and provide better oral function compared to conventional complete dentures.\(^4\) In addition, bite force and masticatory efficiency are greater with overdentures,\(^2^0\) and consequently patients have greater satisfaction with these prostheses.\(^3^4\)

When the number, types, and location of implants are evaluated in reference to patient satisfaction, controversies exist. Geertman, et al\(^3^5\) did not find any difference between overdentures (over-bar) (Figures 4 and 5) and hybrid overdentures (Figures 6 and 7) in terms of patient satisfaction.
satisfaction and masticatory efficiency. In this context, “hybrid” is an overdenture that is supported by both implant and alveolar mucosa, with 2 permucosal cylindric implants and a single barclip attachment. However, Tang, et al found that there was greater patient satisfaction with overdentures (over-bar with 4 implants) than with hybrid overdentures (2 implants).

Patient satisfaction should also be considered when masticatory efficiency is evaluated. Many authors confirm that the patient views the conventional denture as a prosthesis with poor aesthetics and general lack of stability. In addition, there is reduced chewing efficiency and chewing comfort with conventional dentures, resulting in a decrease in masticatory efficiency for hard foods. In contrast, the implant-supported denture has greater masticatory efficiency and requires fewer masticatory cycles to reduce food, thus requiring less chewing time.

Allen and McMillan tested the hypothesis that for edentulous patients, improved patient satisfaction with an oral prosthesis would result in improvement in food selection. The authors verified that patients who had problems with dentures and who received implant prostheses reported improved comfort and ability to chew both hard and soft foods. Further, edentulous patients who received satisfactory implant-stabilized or conventional complete dentures noted improved food selection.

**CONCLUSION**

Based on this literature review, the following conclusions can be drawn:

- **Occlusal design and cusp angulations have a direct effect on masticatory efficiency as well as stress transmission into the bone;**

- **Cusps with 30° inclines and lingualized cusps are associated with the best masticatory efficiency and are also preferred by patients;**

- **Implant-supported prostheses produce a greater biting force and masticatory efficiency than conventional dentures;**

- **Conventional dentures produce less bite force than overdentures; overdentures produce less bite force than natural teeth;**

- **Improvement in oral function is directly related to retention, stability, and the type of attachment used for implant-supported dentures;**

- **Patients noted that the implant-supported denture has greater stability, bite force, and masticatory efficiency for soft and hard foods than does the conventional denture.**
REFERENCES


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POST EXAMINATION QUESTIONS

1. Occlusal design/cusp angulation ___.
   a. has a direct effect on masticatory efficiency
   b. has no effect on masticatory efficiency
   c. has a direct effect on stress transmission into bone
   d. both a and c

2. Masticatory force of conventional mandibular dentures is ____ of that of healthy dentate subjects.
   a. 50% to 65%
   b. 40% to 50%
   c. 20% to 40%
   d. 10% to 20%

3. Which artificial teeth are chosen in conventional balanced occlusion?
   a. anatomic teeth with the maxillary lingual cusp occluding on the central mandibular fossa
   b. anatomic teeth with the maxillary buccal cusp occluding on the central mandibular fossa
   c. anatomic teeth in edge-to-edge occlusion
   d. zero-degree teeth in edge-to-edge occlusion

4. Which occlusion may avoid defective contacts and increase in vertical dimension of occlusion?
   a. convenience occlusion
   b. canine protected occlusion
   c. lingualized occlusion
   d. None of the above.

5. Which is the correct statement?
   a. Masticatory force associated with overdentures is less than conventional dentures and less than natural teeth.
   b. Masticatory force associated with overdentures is more than conventional dentures and more than natural teeth.
   c. Masticatory force associated with overdentures is more than conventional dentures and less than natural teeth.
   d. Masticatory force associated with overdentures is equal to conventional dentures and equal to natural teeth.

6. Which has the most effect on masticatory efficiency?
   a. length of the implant
   b. occlusal design and cusp angulations
   c. width of the implant
   d. number of chewing cycles

7. Which statement is true?
   a. Chewing efficiency and patient preference show that 30° teeth and lingual contacts are not better than zero-degree teeth.
   b. Chewing efficiency and patient preference show that 30° teeth and lingual contact are worse than zero-degree teeth.
   c. Chewing efficiency and patient preference show that 30° teeth, lingual contact, and zero-degree teeth have similar results.
   d. Chewing efficiency and patient preference show that 30° teeth and lingual contact are better than zero-degree teeth.

8. Implant-supported dentures have ____.
   a. stability, bite force, and masticatory efficiency equal to conventional dentures
   b. greater stability than conventional dentures but less bite force
   c. greater stability, bite force, and masticatory efficiency than conventional dentures
   d. greater stability than conventional dentures but equal bite force and masticatory efficiency
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